square inch before showing visible set. The breaking strength should run from 55,000 to 60,000 pounds per square inch. A bar a foot long, and of one square inch area, should elongate at least 15 per cent. before breaking.

As it is not always easy to measure accurately the contracted area at the point of rupture, there is no simpler nor better mode of testing ductility than by bending the bar cold, and such a bar should bend double, cold, without any signs of fracture.

Mr. G. Berkeley, in his valuable paper read before the London Institution of Civil Engineers at the session of 1870, states his experience with English irons as follows:—"Experience extending over twenty years, and comprising many thousands of experiments, has proved that a quality of iron can be obtained at the current prices of the day, which will bear the following tests:—

"For plates, an average breaking strength of 20 tons per square inch, and a minimum of 19 tons per square inch, and an average stretch of 1 inch in twelve lineal = 8.33 per cent.

"For angle and T irons, an average breaking strength of 22 tons per square inch, and an average stretch of 1¼ inches in twelve lineal = 10.5 per cent.

"For rivet iron, an average breaking strength of 18 tons per circular inch."

Common American bar iron will not ordinarily bear over 50,000 pounds ultimate strength, will not elongate over 8½ per cent., and will show signs of fracture when bent cold over 45 degrees.

The undersigned have tested iron as brittle as this, and quite unfit to go into a bridge, the breaking strength of which was over 60,000 pounds per square inch.

Engineers should provide such tests in their specifications as will distinguish the two sorts apart, and if they admit the use of the lower grade iron, should discriminate by fixing a larger margin of safety than for the tougher and better iron. If they do not, they will be pretty sure to get the poorer quality, as it costs less money, and the reason why will be shown.

The mode of making refined iron at Phoenixville is to take a high quality of gray forge pig iron, and work it in a furnace by the process technically known as "boiling," the boiling furnace being "fettled" with ore. This pig iron when "brought to nature" is balled up in the furnace in the usual way, squeezed in a Burden squeezer, and then rolled into a flat bar, technically known as a "muck bar," or No. 1 bar.

From each heat so made one bar is taken and bent to an angle of 45 degrees cold; if it stands without any signs of fracture the heat is passed as good, if not, it is rejected.

The iron that has passed this test is piled, charged in a heating furnace, heated and rolled into flat bars. This is called No. 2 bar, and is sold as "Phoenix Best." The iron so rolled is again cut, piled, and rolled into the finished bar, and is called No. 3 bar, and is the iron sold by the Phoenix Iron Co. as "Phoenix Best Best." A bar of this iron, 2½ inches diameter, has been bent cold so that the sides came in close contact without showing the least signs of fracture.

It should be borne in mind that the object of reworking iron is to refine it by getting rid of the surplus cinder and scoria, making the iron firm in texture and of a more uniform quality. This uniformity of quality results from the fact that the pile from which a bar of No. 2 is made consists of fourteen No. 1 bars, and the pile of No. 3 of eight No. 2, so that if by chance an inferior muck bar had been used, it would form but 1/12 part of the No. 3, or "Best Best" bar.

All iron improves up to the third working, but if the quality of the pig is not suitable no amount of working will make the product good iron; hence the necessity for tests as to toughness and stretching.

The ordinary iron of commerce is made, as a rule, from an inferior quality of pig, is frequently worked in its conversion from carbonate to metallic iron by the process practically known as puddling, instead of boiling, and is only once worked from the puddle or muck bar, corresponding to No. 2 iron.

It is also made sometimes from scrap iron and often from old rails. Neither of these modes gives reliable iron, as there is no certainty of the quality of the scrap used, though bar iron made from scrap is ordinarily reckoned as good quality. Iron from old rails is always inferior, and not to be trusted for the uses of a high-grade iron, as rails are generally made in the first place of inferior iron.

Hence it follows that a reliable iron for bridge purposes should be made of a known quality of pig, worked in the best way in the boiling furnace, tested in the muck bar, and cut, piled, heated, and rolled once or twice thereafter, according as single- or double-refined iron is needed.

It is not to be expected, nor is it desirable, that the engineer should dictate the process of manufacture, but he should establish such tests in his specification as will distinguish an inferior iron from a high quality of iron, and what these tests should be has been previously stated.